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Velocity and Inflation Expectations: 1922-1983

Michael W. Keran*

Economic theory suggests that a change in inflation expectations can affect velocity by changing the spread between real and nominal interest rates, and empirical evidence from 1922 to 1983 indicates that major changes in velocity have been associated with changes in inflation expectations.

The major policy implication is that when there is a major *change in inflation expectations, the resulting change in the demand for money should be accomodated by the monetary authorities to prevent disruption to the real economy. Such a policy implies targeting* real *interest rates. However, aside from the rare instances when inflation expectations and thus velocity changes are large, targeting the nominal money supply is the superior operating technique for the central bank.*

In 1982, the Federal Reserve reduced the importance it placed on the narrow definition of money—M1—as a guide to setting monetary policy because of a breakdown in the historic relationship between M1 and nominal GNP. The velocity of M1 had risen at a relatively stable 3 percent rate from 1952 to 1981, but suddenly, in 1982-83, the velocity of M1 declined by an unprecedented 5 percent. The only other year since World War II that velocity declined was 1954, and that was by a relatively modest ½ percent. One had to look back to the 1930s to find a decline in velocity equal to that in 1982-83.

Any central bank under the same circumstances faces the major policy question: Does such a large change in velocity mean that M1 is no longer a reliable guide to policy? The answer depends on the source of the decline in velocity. If the velocity decline were a random or unique event in the sense that it cannot be explained by standard economic theory as imbedded, for example, in a demand for money equation, then a strong case can be made to abandon M1 as a guide to policy at least temporarily.

There are a number of recent economic and institutional factors leading to such a conclusion:

1. *Deregulation*—The deregulation of banks, specifically the permission to pay interest on transactions deposits and on very close substitutes, has permitted banks to issue deposits that have transactions characteristics and that are more attractive to depositors as savings vehicles because they pay explicit interest. Deregulation, by changing the relative attractiveness of various classes of deposits, could fundamentally change the public's demand to hold M1. For example, the unprecedented increase in economic risks and uncertainty associated with the 1981–82 business cycle contraction could have induced the public to hold larger precautionary balances in deregulated M1 than would otherwise have been the case. This would have temporarily reduced velocity.

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2. *Financial innovation*—When deregulation does not keep pace with expanding financial opportunities or the means to take advantage of them, the financial markets may develop innovations around regulations. Money market mutual funds are a recent example of this process. These accounts pay market interest rates and play a limited transactions role. Their existence could cause the public to hold a significant part of its transactions deposits outside the traditionally defined measures of M1. The standard arguments explaining demand for M1 may no longer work if there were a significant increase in the share of the transactions balances held in non-M1 form.

In both cases, the net result would be that the standard demand for money equation, which relates real money balances to real income and nominal interest rates, would no longer be able to explain the growth in the public's demand for money. Because deregulation, financial innovation, and uncertainty factors may continue to play a significant role in money demand, one could well expect further shifts in velocity. Moreover, it would take several years within a new stable environment before one could set M1 targets that have predictable consequences for GNP.

An alternative explanation for the decline in velocity in 1982-83 is that it was associated not with a shift in the demand for money but rather with an unprecedented change in the factors which determined the demand for money—a movement along the demand curve. In this case, we would have sufficient information to set appropriate targets for M1 because the money demand equation remains stable. Past articles in this Review have analyzed the issue and concluded that the demand for M1 was stable during the 1982-83 period. According to those analyses, the major factor operating on velocity in this episode was the unusually large decline in inflation and interest rates.[1] This decline led to an increase in the demand for money relative to income and a decline in velocity.

If a decline in velocity can be explained within the context of a stable demand for money function, then the monetary authorities can continue to rely on M1 as a guide to policy. The statistical analysis supporting this conclusion was based on data from the mid-1970s to 1982.

The purpose of this article is to extend the earlier work in both theoretical and empirical domains. This will be done with a systematic theoretical analysis of the effects of interest rates and inflation expectations on velocity and by incorporating other episodes where velocity has declined substantially to see if they also can be explained by major declines in inflation and interest rates.[2] Because such episodes have been so unusual, we must look at a range of U.S. economic history that extends back to the early 1920s. We will look at velocity equations using annual data from 1922 to 1983 to discover whether the most recent experience is consistent with past relationships.

Some analysts would argue that using data from the pre-war period is not useful because the institutional factors that determine both GNP and the money stock have since changed in profound ways: (1) the government sector makes up a much larger share of GNP than in the past, and government regulation affects a significant part of the private component of GNP; (2) technological innovation has greatly reduced the need for holding transactions balances relative to GNP; and (3) international trade and capital flows have tied the U.S. economy more closely to the rest of the world.

These and other considerations could have fundamentally altered the velocity relationship over time. In these circumstances, velocity would not necessarily respond to the same set of factors in the two periods. These considerations imply that using pre-war data on velocity to help explain the post-war movements in velocity may be a futile exercise. However, if the evidence supports the proposition that velocity in both periods can be explained by the same set of factors, we can reasonably infer that—given all of the apparent differences between the two periods—the differences are not sufficient to have a major effect on the public's demand for money and/or velocity. The results reported below support the proposition that the 1982-83 decline in velocity can be explained by the same factors that have determined velocity since 1922. We conclude, therefore, that M1 can be used as a reliable guide to policy in the future.

In Section I, we lay out the theoretical underpinnings of the casual discussion above. In Section II, we present the empirical relationships, and, in Section III, the policy conclusions and summary.

I. Theoretical Considerations

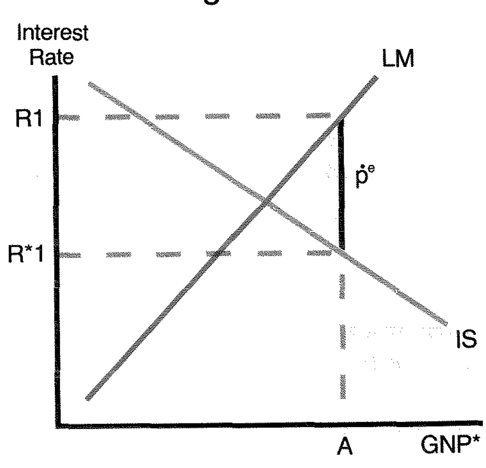
The economic behavior by households and businesses that lies behind the money/income relation we summarize with the term velocity can be analyzed within a Keynesian theoretical framework. This framework defines the conditions that determine the equilibrium supply and demand for money (the LM curve) and the equilibrium conditions that determine the demand for goods or real GNP (the IS curve). These relations are summarized in Figure 1.[3]

Assuming that the supply of money is determined by the monetary authorities, the LM curve defines the public's real or price-adjusted demand for money. This real money demand is influenced by two factors—real GNP and *nominal* interest rates. As GNP increases, the public's demand for money increases to meet its greater transaction needs. As nominal interest rates rise, the public reduces its demand for money because the "opportunity cost" of holding money has increased. The slope of the LM curve represents that combination of higher GNP and higher interest rates that will hold the demand for money equal to a constant supply of money as determined by the central bank.

The IS curve (Investments/Savings) illustrates that combination of *real* interest rates and real GNP that will equate "savings" and "investment". Investment (and government spending) are determined independently of GNP. Investment will increase with lower real interest rates (the real interest rate is the nominal interest rate less the expected rate of inflation) because the profitability of an investment depends on whether the internal rate of return on that investment is sufficiently high to pay the interest cost. The lower the real interest rate, the larger the number of investment projects that will have an internal rate of return high enough to be profitable. Savings (and tax receipts), in contrast, are primarily a function of GNP. High levels of GNP lead to high levels of savings and tax receipts. Historically, savings have been found to represent a rather stable share of GNP over long periods of time, irrespective of the level of real or nominal interest rates.

The equilibrium conditions for the demand for real GNP (omitting international considerations) require that investment (plus government spending) equals savings (plus tax receipts). The slope of the IS curve shows that the equality of savings and investment is achieved when real interest rates fall and real GNP rises. A fall in real interest rates increases investment while a rise in real GNP will increase savings.

Figure 1



In Figure 1, the velocity of money is the ratio of real GNP measured on the horizontal axis to the fixed quantity of real money implied in the LM curve. Any movement along the LM curve would imply a change in velocity with a stable demand for money. When inflation expectations are positive ($\dot{P}^e$), they will drive a wedge between the LM and IS curves. At the same level of real GNP (point A), the *nominal* interest rate that will equate the supply and demand for money will be at R1. The *real* interest rate that equates savings and investment will be at R*1. The difference is equal to the expected rate of inflation ($\dot{P}^e$). A fall in the expected inflation rate will reduce the wedge between the LM and IS curves and thereby reduce GNP and velocity. A rise in the expected inflation rate will increase the wedge between the LM and IS curves, and raise GNP and velocity. The latter results because in each example the real money stock is being held constant and real GNP is changing.

Comparative Statics

The effect of nominal interest rates and inflation expectations on velocity is illustrated in a different way in Figure 2. In the long-run, real GNP will be at a level consistent with equilibrium utilization of our capital and labor resources. This can be referred to as full employment. Assuming such a level of GNP is represented by YF, there can be a wide range of real demands for money, and thus, levels of velocity, depending upon the level of inflation expectations. If inflation expectations were high (equal to $\dot{P}^e$), nominal interest rates would be high, the demand for and supply of money would be relatively low (as represented by LM′), and velocity would be high. If inflation expectations were zero, nominal interest rates would be low (equal to real interest rates) and the demand for and supply of money would be higher (LM″) with a corresponding lower level of velocity. Thus, in the long-run, a fall in inflation expectations will lead to a fall in nominal interest rates, a rise in the demand for real money, and a once and for all decline in velocity.

In each of the steady state conditions described in Figure 2, real interest rates and real GNP are at the same unchanged levels determined by the relative endowments of capital, labor and technology. The only differences between these steady states are the levels of inflation expectations and nominal interest rates that change the real demand for money and velocity.

In principle, other factors could affect velocity besides inflation expectations. For example, an increase in the internal rate of return on capital could increase the steady state level of real GNP (that is, shift the IS curve to the right) and lead to a parallel rise in real and nominal interest rates, a lower demand for money, and a higher level of velocity.[4] Alternatively, a permanent easing of fiscal policy through structural budget deficits could lead to a parallel rise in real and nominal interest rates and, through the same process described above, to a rise in the level of velocity.[5]

The Transition Period

The transition from one inflation expectation environment to another would depend upon the monetary control rule followed by the central bank. Three such monetary control rules can be identified: (1) targeting real interest rates, (2) targeting the nominal money stock, and (3) targeting the nominal interest rate. The implication of each of these control rules is illustrated in Figure 3 under the assumption of a major decline in inflation expectations.

With a real interest rate target (Alternative 1), the decline in inflation expectations would require a full parallel decline in nominal interest rates. The central bank could achieve this by permitting the nominal money stock to increase, thereby shifting the LM curve to the right (LM 1). Under this monetary control rule, the short-run results for money, income

Figure 2

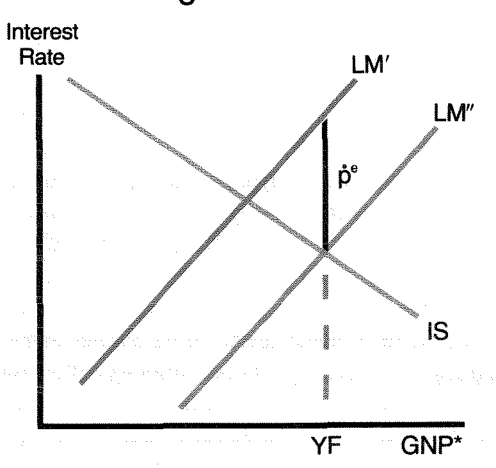
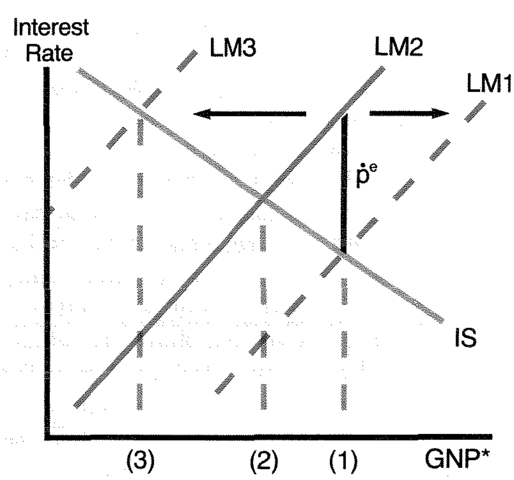


Figure 3



and interest rates would be the same as the long-run results (described in Figure 2). That is, the full employment level of real income would remain unchanged at Point 1, and the increase in the desire to hold real money stock would be satisfied by an increase in the nominal money supply.

Under Alternative 2, keeping the nominal money stock unchanged, the LM curve would be unchanged at LM 2 in Figure 3 in the short-run. Nominal interest rates would fall by some fraction of the decline in inflation expectations and real interest rates would rise so that, in the short-run, real GNP would fall to point 2, below the full employment level of GNP. Over the longer run, however, the higher real interest rates and lower real GNP will cause the price level to fall. Under a nominal money supply target, this would lead to a rise in real money supply and a rightward shift in the LM curve. The rise in real money balances would continue until such time as prices stopped falling and stabilized at a new, lower level. This would occur when real GNP had increased to its full employment level (Point 1) in Figure 3. Thus, the long-run results of Alternative 2 (targeting nominal money supply) would be the same as the long-run results of Alternative 1 with respect to real income. The difference would be that the price level would be lower under Alternative 2. Furthermore, in the short-run or transition period, real interest rates would be higher and real GNP would be lower under Alternative 2.

Under a nominal interest rate target (Alternative 3), a decline in inflation expectations would cause the central bank to reduce the nominal money supply in the short-run to LM 3. This would force real interest rates to rise by an amount equal to the fall in inflation expectations, reducing real GNP to Point 3. Over the longer run, the higher real interest rate and lower real GNP will cause the price level to fall. While this would, *ceteris paribus*, raise the real money stock as in Alternative 2, the central bank could offset the rise by further reducing the nominal money supply to keep nominal interest from falling. Furthermore, with expectations of price deflation, the real interest rate would rise above the nominal interest rate, inducing further declines in real GNP and prices. Each fall in prices would contribute to maintaining "deflation" expectations and real interest rates above the nominal rate. There would be no theoretical limit to the size of the fall in prices and real GNP would be "permanently" below its full employment level under this nominal interest rate rule.

What the preceding discussion shows is that a fall in inflation expectations will by itself tend to raise real interest rates and lower real GNP. This process can only be offset by a decline in nominal interest rates in the full amount of the decline in inflation expectations. The central bank can achieve this result only by allowing the money supply to increase in line with the fall in nominal interest rates. If the central bank does not allow this monetary accommodation, one of two results will occur. Under a money supply rule (Alternative 2), the effect in the short-run would be higher real interest rates and lower real GNP; in the long-run, it would be a low price level. Under Alternative 3 (nominal interest rate target), the price level would decline without limit and real GNP will be permanently less than its level at full employment.

Interpreting the Model

The equation used to estimate the effects of inflation expectations and nominal interest rates on velocity, as formally derived in the appendix, has the following form:

$$\Delta \ln(V) = a_0 + a_1 \Delta \ln(R) + a_2 \Delta (\dot{P}^e)$$

The change in velocity is a function of both the change in the nominal interest rate and the change in inflation expectations.[6] The coefficient on the interest rate variable (a_1) measures the partial effect of a change in nominal interest rates on velocity holding inflation expectations unchanged. This is the case where real and nominal interest rates change together. A change in nominal interest rates affects velocity directly through a change in the demand for money, whereas a change in real interest rates affects velocity indirectly through its effects on real GNP. These two forces tend to have opposite effects on velocity. For example, a rise in nominal interest rates will reduce the demand for money and raise velocity. In contrast, a rise in real interest rates will reduce real GNP and reduce velocity. The strength of this last effect depends on the income elasticity in the demand for money. If that elasticity were 1, then changes in GNP would lead to proportional changes in the demand for money and no effect on velocity.

However, if, as most statistical estimates suggest, the income elasticity is somewhat less than 1, a decline in GNP will lead to a proportionally smaller decline in the demand for money and, therefore, a fall in velocity. Thus, the a_1 coefficient would be the sum of the positive value coming from the LM curve of a change in nominal interest rates and the negative value coming from the IS curve of a parallel change in real interest rates.

The coefficient on inflation expectations (a_2) measures the partial effect of a change in inflation expectations holding nominal interest rates unchanged. As such, this influence works only through the goods market and GNP and has an unambiguously positive sign. For example, a rise in inflation expectations will lead to a fall in real interest rates and therefore a rise in real GNP. Because the income elasticity of the demand for money is less than unity, the rise in GNP will raise velocity.

A parallel change in nominal interest rates and inflation expectations would be measured by both the a_1 and a_2 coefficients. They would represent the effects on velocity coming from the LM curve without any velocity effects coming from the IS curve because real interest rates and, thus, real income, would be unchanged.

This discussion suggests that if the Federal Reserve followed a real interest rate policy that allowed all changes in inflation expectations to show up as changes in nominal interest rates, the policy-induced change in velocity would be measured by both of the coefficients a_1 plus a_2. However, if the Federal Reserve followed a nominal interest rate policy—that is, allowing changes in inflation expectations to affect only the real rates, then the policy-induced effects on velocity would be measured only by the a_2 coefficient. If the Federal Reserve followed a money supply rule, the policy-induced effects on velocity would fall somewhere between the two interest rate rules because both real and nominal rates would change.

Policy Implications

One should not infer from this analysis that targeting real interest rates is always a superior monetary policy instrument. There are two reasons for skepticism. First, the real interest rate is not a measurable series, while nominal interest rates and money are measurable to a reasonable degree of accuracy.[7] It is possible, therefore, to make a mistake in attempting to apply a real interest rate target. Second, as demonstrated in the empirical section to follow, the interest rate effect on velocity is rather small and major changes in inflation expectations are needed to produce the analytical results discussed above. Such large changes in inflation expectations are a relatively rare phenomena and therefore should not be used routinely for setting monetary policy targets. Money is clearly superior to nominal interest rates as a guide to controlling generally GNP and, under most normal circumstances, is generally superior to real interest rates because of measurement problems with the latter.

II. Empirical Relations

Overview

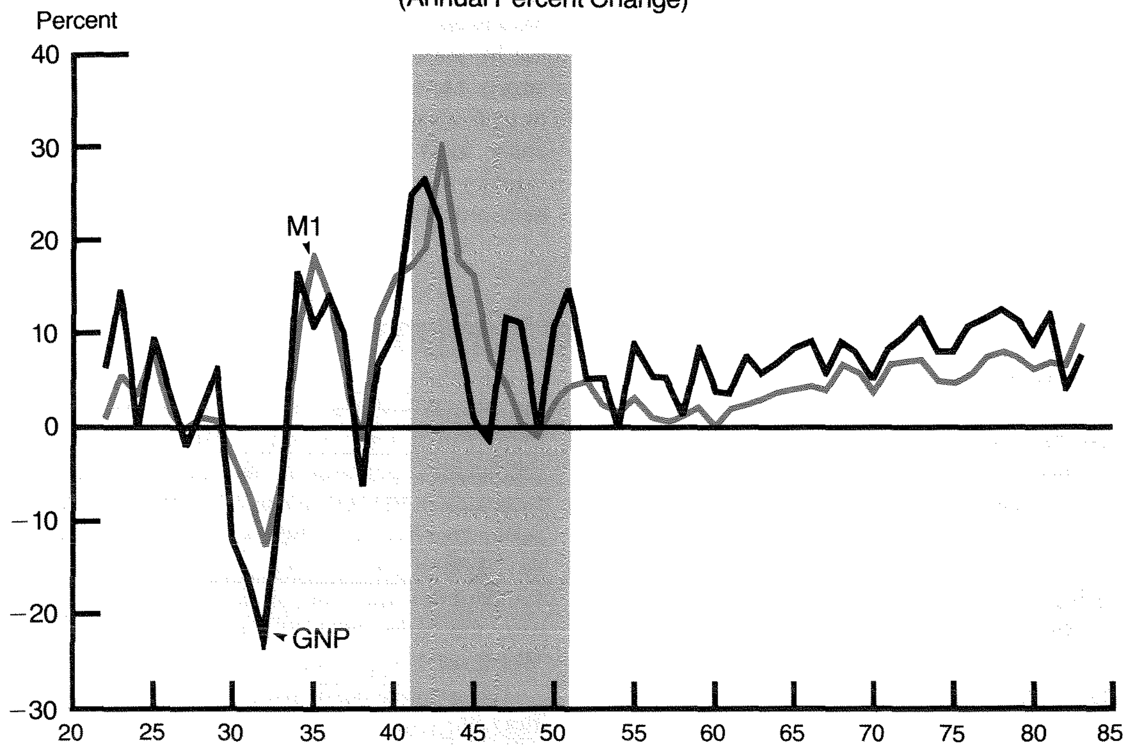
Over the broad sweep of U.S. economic history, there has been a close link between changes in M1 and changes in nominal GNP. Chart 1 shows annual rates of change in M1 and nominal GNP from 1922 to 1983. Except for World War II and its immediate aftermath (shown as a shaded area), the year-by-year changes in nominal GNP are rather closely matched by changes in M1. In the pre-war period of the 1930s, the major decline in income was associated with a major decline in M1. The rapid growth in income in the mid-1930s and the 1937-38 recession were also associated with the rise and fall in M1.[8] In the post-World War II years from 1952 to 1981, there was a long period of relatively stable and predictable increases in income associated with increases in M1. On average, GNP grew 3 percent faster than M1, from 1952 to 1981, with a standard deviation of about 1.8 percent. This contrasts with a standard deviation for the money/GNP relationship over the entire 1922-1983 period (omitting World War II) of 4.5 percent.

The apparent break in the money/GNP relation in 1982-83, while it was out of line with the previous 30 years, was a relatively modest change when viewed over the past 60 years. It is interesting to note that GNP tended to reinforce and not offset the movements in M1. That is, a decline in M1 would lead to a more than proportional decline in GNP, such as in the early 1930s. The one year when the decline in velocity was offset by a rise in M1 was 1983 (more on this later).

These large shifts in the money/GNP relationship are, of course, reflected in the movements in velocity. The pattern of velocity, with its associated movements in interest rates, is shown in Chart 2 (World War II and its immediate aftermath are omitted from Charts 2-4.). In the pre-war period of the 1920s, both velocity and interest rates were first relatively flat; they declined substantially in the early 1930s and remained at a historically low level through World War II, until the Fed-U.S. Treasury accord in 1951.[9] In the post-war period after 1952, velocity tended to rise steadily with the rise in interest rates. As economic theory would suggest, much of the movement in velocity in the United States in the last 60 years can be explained by the movement in nominal interest rates.

Chart 3 shows the same relation between nominal interest rates and velocity in year-over-year changes in log form (omitting 1941-51). This way of presenting the data brings out clearly the close association between nominal interest rates and velocity. During the pre-war period (1922-40), there were much larger variations in both interest rates and velocity than in the post-war period (1952-83). Thus, the decline in velocity in 1982-83, while it was by far the largest in the post-war period, was relatively small compared to, for example, 1930-33 or 1938-39. The unusual stability in the growth of velocity in the last thirty-plus years is at least partially due to the relatively smaller variations in interest rates. Nevertheless, during the 1970s, the stability of velocity was greater than that which would be explained purely by underlying movements in interest rates.

Chart 1
M1 and GNP
(Annual Percent Change)

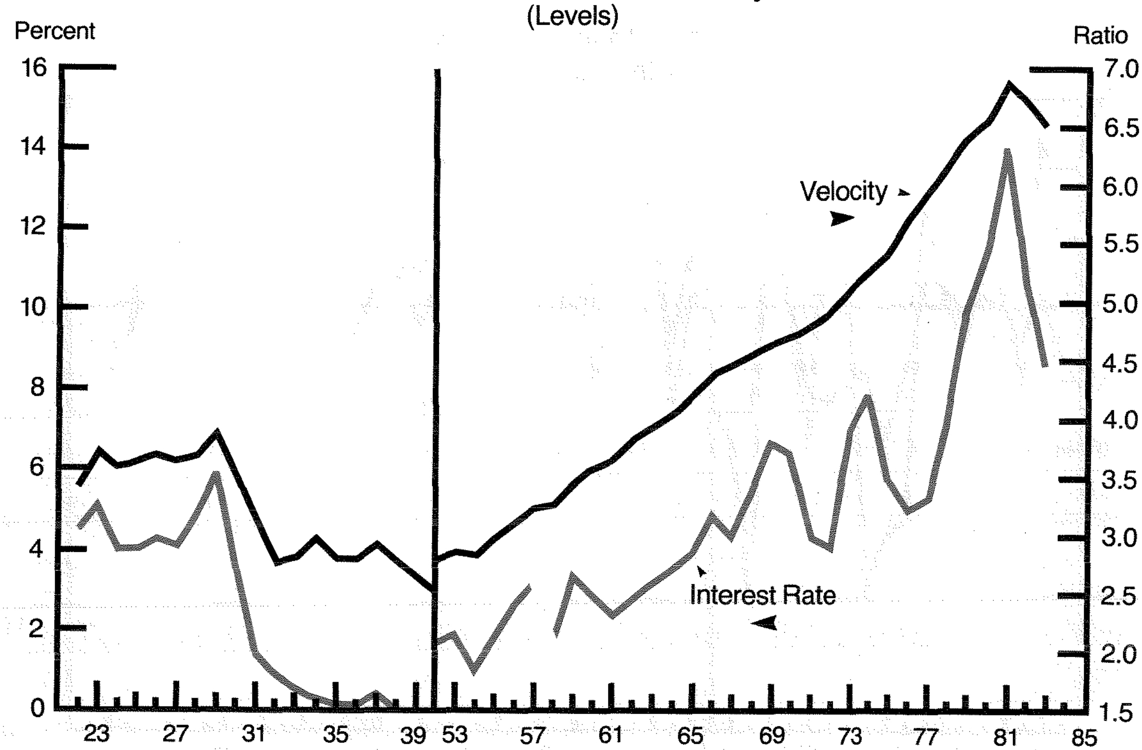


For example, the decline in interest rates in 1971-72 and 1975-76 did not appear to affect velocity significantly. This contrasts sharply with the response of velocity in other periods (including 1982-83) to a decline in interest rates. Some special factors might explain the lack of response in the 1970s. Wage and price controls, imposed in August 1971, could have affected interest rates but not velocity. Again in 1975-76, there was a well-documented and statistically significant downward shift in the demand for M1 that would have offset the effect of a decline in interest rates on velocity.[10] These episodes could have masked the underlying relationship between interest rates and velocity. We will consider that issue further in the formal statistical section of this paper.

The relation between inflation and interest rates is shown in Chart 4 for the period from 1922 to 1983. In the post-World War II era, from 1952-1981, the gradual rise in interest rates was matched by a parallel rise in the inflation rate. Furthermore, many of the year-to-year changes in interest rates were associated with parallel changes in the inflation rate. During the 1950s and 1960s, when the inflation rate was relatively low, the interest rate averaged one to two percent above the inflation rate. During the 1970s, when the inflation rate was relatively high, the interest rate averaged between zero and one percent below the inflation rate. Starting in 1980, the interest rate has moved sharply above the inflation rate, declining in 1982-83 only with a drop in the inflation rate.

The link between interest rates and inflation rates before World War II (1922-40) was not as close as in the post-war period. However, the changes in inflation and interest rates were similar. For example, the major decline in interest rates in 1929-33 was associated with a major fall in inflation (actually deflation). The decline in nominal interest rates, however, was less than the price deflation because

Chart 2
Interest Rate and Velocity
(Levels)

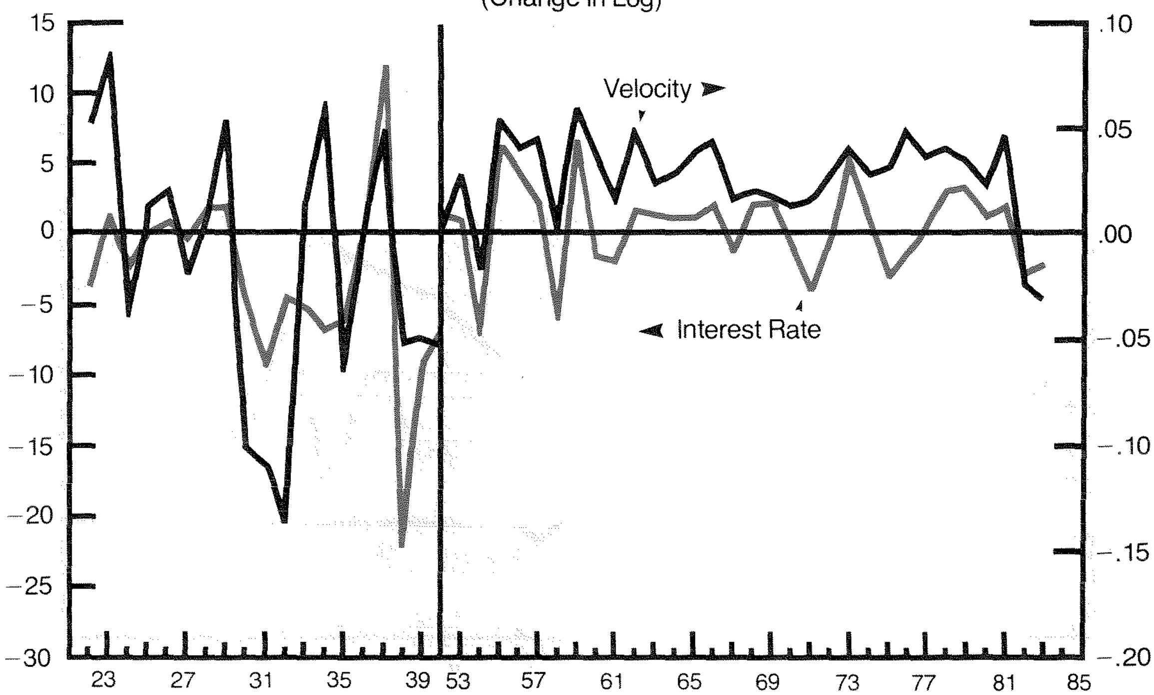


prices fell an average of seven percent per year for four years while the nominal interest rate could not fall below zero. As a result, the real interest rate during the Great Depression reached its highest level of any time in the sixty years covered by this study.

This example illustrates one of the major points brought out in the theoretical discussion in Section I. In an episode of major decline in inflation expectations, targeting nominal interest rates destabilizes the economy. During the 1930-33 period, the monetary authorities defined policy in terms of the level of nominal interest rates. There is ample evidence that they thought they were following an easy monetary policy during this period because nominal interest rates fell to new historic lows.[11] Instead, this nominal interest rate policy in the face of a major decline in inflation expectations led to a substantial rise in real interest rates. It is also clear that the monetary authorities did not follow a money supply target, because M1 declined by over 30 percent in those four years. Only when this nominal interest rate policy was abandoned in 1934 did output and prices start to recover. That was done indirectly by raising the price of gold from $20 to $35 an ounce, making it attractive for foreigners to sell gold to the United States. According to the then-established rules of central banking, the Federal Reserve monetized the gold inflow, and thereby increased the liquidity of the banking system and the money supply.[12]

This nominal interest rate targeting episode can be contrasted with the monetary authorities' response to the decline in inflation expectations in 1982-83. In this later case, it could be argued that the Fed followed a *de facto* real interest rate target. That is, nominal interest rates were allowed to fall in line with the decline in inflation. This could only be accomplished by allowing the nominal money stock to rise substantially to satisfy the increased desire to hold real money balances at lower nominal interest rates. As a result, real interest rates were kept from rising and real GNP increased substantially in 1983. This is the only episode in the sixty

Chart 3
Interest Rate and Velocity
(Change in Log)



years covered by the study when a decline in velocity was matched by an increase in the money supply which neutralized the effect on real interest rates and real GNP of a decline in inflation expectations.

Statistical Analysis

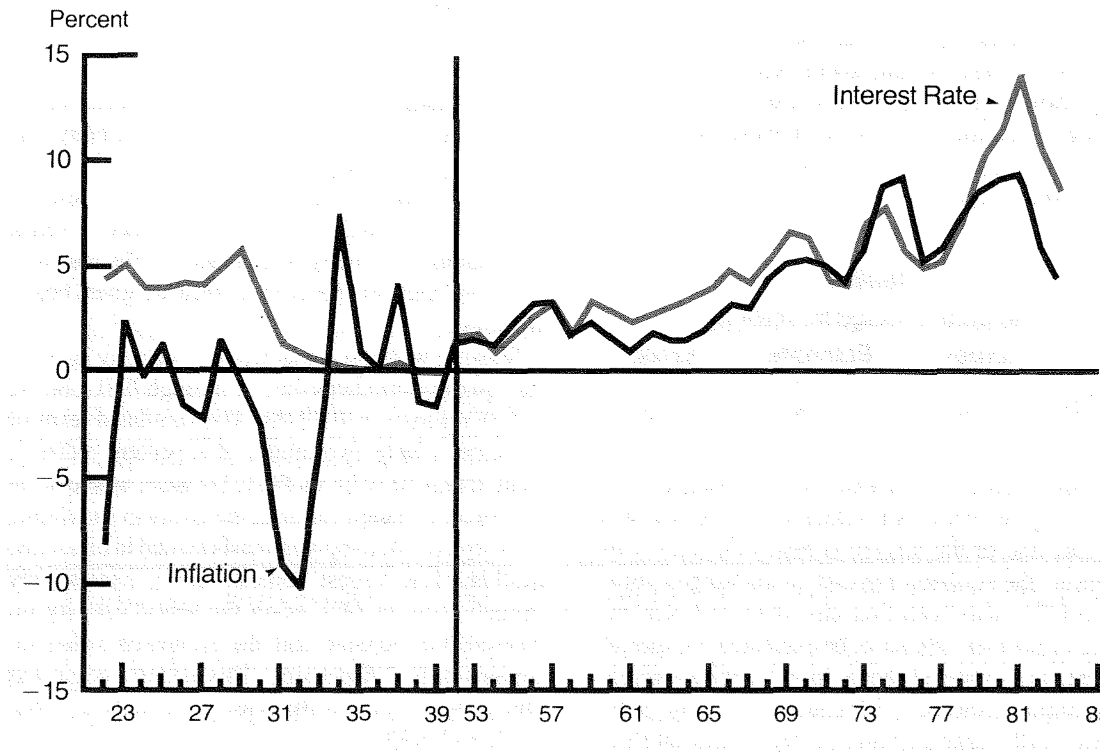
In Section I and more formally in the appendix, we show that both the nominal interest rate (R) and inflation expectations ($\dot{P}^e$) would have an important influence on velocity.[13] In this section, we will test those propositions with formal statistical procedures using annual data from 1922 to 1983 (omitting 1941-51). The interest rate is for short-term U.S. Treasury securities (after 1952, the three-month Treasury Bill rate).[14] Inflation expectations are approximated by the actual inflation rate as represented by the GNP price deflator. This is a common measure of inflation expectations especially in association with short-term interest rates. Velocity is measured as the ratio of real GNP to real M1 (currency and all transactions deposits in the hands of the non-bank public). The results of estimating an equation in first difference of logs with a lagged dependent variable, to measure lagged adjustment, is given below (t statistics are in brackets below the estimated coefficients).

$$\Delta \ln(V) = \underset{(2.4)}{.0098} + \underset{(4.4)}{.039}\,\Delta \ln(R) + \underset{(5.0)}{.0068}\,\Delta(\dot{P}) + \underset{(3.5)}{.30}\,\Delta \ln(V)_{-1}$$

R^2/SE .61/.030
D W/Rho 1.99/−.097
(0.7)

Over the period since 1922, changes in velocity have been significantly correlated with changes in nominal interest rates and inflation. Based on the value and statistical significance of the lag dependent variable $\Delta \ln(V)_{-1}$, 70 percent of the adjustment of velocity to interest rates and inflation occurs in the

Chart 4
Interest Rate and Inflation



first year. It takes a relatively large movement in interest rates to affect velocity. For example, a 10 percent change in nominal interest rates, say, from 10 percent to 11 percent (holding inflation constant), would lead to a first year change in velocity of about .4 percent. Alternatively, a 1 percentage point change in inflation from 10 percent to 11 percent (holding nominal interest rates constant) would lead to a first year change in velocity of about .7 percent. We can therefore infer that a parallel change in nominal interest rates and inflation from 10 percent to 11 percent would mean a first year change in velocity of about 1.1 percent. (In the general case, these coefficients are not strictly additive because the percent change in interest rates depends on the base levels.)

These empirical results confirm the earlier theoretical discussion that showed that parallel changes in nominal and real interest rates would have a smaller effect on velocity (.4 percent) than parallel changes in nominal interest rates and inflation expectations (1.1 percent). The reason for this result is that real interest rates have an opposite effect on velocity than nominal interest rates, as long as the income elasticity in the demand for money is less than one.[15]

The estimated and actual values of changes in velocity in 1982–83 are given below in Table 1. They show that the equation was successful in predicting a decline in velocity in those two years, although it missed the size of the decline by a fairly substantial amount.[16]

Table 1
Percent Change in Velocity

	Actual	Estimate	Error
1982	−2.4	−1.2	1.2
1983	−3.0	−1.7	1.3

Furthermore, the equation also forecast a decline in velocity in 1976 when velocity actually rose 4.9 percent, one of the largest increases on record. In addition, the equation forecast an unchanged velocity in 1971, when actual velocity rose by 1.6 percent. These errors can, of course, be explained, by special factors, as mentioned above. In 1971, price controls were imposed on the U.S. economy. And, in 1976, a historically large and empirically significant shift in the demand for money took place. Adding dummy variables for these two episodes greatly improves the statistical fit of the equation and also reduces the error for forecasting the velocity in 1982-83. However, such adjustments raise important methodological issues in economic theory that call their usefulness into question.

If in fact a series of events that temporarily loosened the relation between velocity on the one hand and interest rates and inflation on the other buffeted the 1970s, there is a simple technique for dealing with the problem if we believe the problem is now over. We can estimate the equation through 1970 and then forecast velocity on the basis of those estimates in the 1980s. We followed this procedure and give the estimate of velocity in the period 1922-1970 (again omitting 1941-51) below.

$$\begin{aligned}\Delta \ln (V) = \underset{(1.6)}{.0076} + \underset{(4.2)}{.041}\, \Delta \ln (R) \\ + \underset{(4.9)}{.0073}\, \Delta (\dot{P}) + \underset{(3.4)}{.31}\, \Delta \ln (V)_{-1}\end{aligned}$$

R^2/SE .64/.031
D W/Rho 2.03/−.17
(1.1)

The results are very close to the estimate for the whole period, except that the trend in velocity (the constant term) is slightly lower and the coefficient values on interest rates and inflation are slightly higher. This equation is used to produce dynamic simulations of velocity from 1980-83. The results in both level and percent change form are given below in Table 2.

Starting with the actual value of velocity in 1979, the equation simulates the rise through 1981, and the fall of velocity in 1982-83. The simulated level of velocity is only two-tenths of a percent different from actual velocity in 1983, because, as shown in the percent change column, the errors in simulating velocity on a year-by-year basis tended to offset one another. The largest forecast error, interestingly enough, was in 1981 when the actual velocity increased 4.8 percent and the simulated value increased only 2.6 percent. This underforecast was offset by modest overforecast of velocity in 1980, 1982, and 1983.

Table 2
Velocity Simulations

Year	Actual		Simulated		Percent Error	
	Level	Percent Change	Level	Percent Change	Level	Percent Change
1979	6.40	—	—	—	—	—
1980	6.55	2.3	6.59	3.0	0.5	0.7
1981	6.87	4.8	6.76	2.6	−1.5	−2.2
1982	6.70	−2.2	6.62	−2.1	−1.1	0.1
1983	6.50	−3.0	6.49	−2.0	−0.2	1.0

Policy Implications

The theoretical analysis and empirical evidence considered in this article lead to the conclusion that when there is a major change in inflation expectations, it is better to target real interest rates than to target nominal interest rates or even the nominal money stock. The analysis, however, also indicates that under most circumstances, the preferred monetary target of the central bank should be the nominal money stock. There are two reasons for this preference. First, the money stock can be measured directly, while real interest rates can be measured only indirectly with the possibility of a large measurement error. Second, the large changes in inflation expectations needed to have a large effect on velocity occur rarely. Thus, the need for a monetary target focusing on real interest rates also would be rare.

This point is illustrated in Chart 1, which shows that there has been a close historic relation between money and GNP over the 1922-83 period. Deviations in this relation have occurred only in periods when very large parallel changes in interest rates and inflation led to substantial changes in the public's desire to hold money relative to income. This impression is confirmed when annual changes in the real GNP are compared to annual changes in real M1 and interest rates from 1922 to 1983.[17]

$$\Delta \ln(\text{GNP}^*) = \underset{(3.3)}{.019} + \underset{(7.0)}{.86}\, \Delta \ln(\text{M1}^*) + \underset{(4.9)}{.051}\, \Delta \ln(\text{R})$$

R^2/SE .57/.036
DW/Rho 1.48/.035
(0.3)

For every one percent increase in real M1, real GNP will increase by .86 percent. For every one percent increase in nominal interest rates, real GNP will increase by .05 percent. Both of these influences on GNP are significant statistically. However, the magnitude of the M1 influence is almost twenty times greater than the magnitude of the nominal interest rate influence. We surmise that it takes very large changes in nominal interest rates to cause GNP to move in ways other than that associated with changes in M1.[18]

III. Summary and Conclusions

Most of the literature in monetary economics describes the link between changes in money on the one hand and changes in GNP and inflation on the other hand. The purpose of this article is to show that when there are large changes in inflation expectations, there can be a large change in velocity. The reason for this reverse link between inflation and the GNP/money relation is based on the fact that the demand for money depends on the nominal interest rate while the demand for GNP depends upon the real interest rate. Thus, changes in inflation expectations will change the spread between nominal and real interest rates in such a way as to have opposite effects upon the demand for money and GNP. For example, a fall in inflation expectations will simultaneously lead to a fall in nominal interest rates and/or a rise in real interest rates such that the demand for money goes up and real GNP goes down. Both forces would operate to lower velocity.

This article shows that the link between inflation expectations and nominal interest rates to velocity is statistically significant. However, because major changes in inflation expectations are rare, major changes in velocity also are rare. For example, there has been only one major decline in velocity since World War II.

The implications of these results for monetary policy are as follows. Under most circumstances the Federal Reserve policy of targeting M1 will result in reasonably accurate control of the GNP in the short-run and inflation in the longer run. However, in those episodes when there has been a major change in inflation expectations, the Federal Reserve would have a strong case for "targeting" real interest rates rather than M1. Because of problems measuring real rates, such a targeting procedure would necessarily be crude. Nevertheless, developments in 1982-83 that allowed the nominal interest rate to fall in line with the fall in actual inflation were reasonable. In such circumstances, the Federal Reserve would allow money supply growth to accommodate whatever changes in the demand for money came from the such a change in nominal interest rates.

If a nominal interest rate is targeted when there is a major decline in inflation expectations, the resulting rise in real interest rates would choke off the growth of real GNP. The fundamental fact is that the decline in inflation will increase the desire of the public to hold money. If this is not satisfied by the central bank's increase in the supply of money, then it will be satisfied by the public through a rise in real interest rates and a fall in GNP. That is precisely how the public achieved its desired increase in money balances during the great deflation of the early 1930s.

It can be argued that the Federal Reserve action in October 1982 to reduce the role of M1 as a guide to policy was consistent with a movement to a real interest rate target during a period of declining inflation expectations. The decline in actual inflation by that date was sufficiently large to make it clear that a substantial decline in at least short-run inflation expectations was occuring. As shown in Chart 4, short-term nominal interest rates were allowed to fall by the full amount of the decline in inflation, and M1 was allowed to rise substantially above its long-run target range. According to the analysis of this article, that is the appropriate response of a central bank to a major decline in inflation.

If the decline in inflation expectations is now over, the decline in velocity should also be over. The resumption of normal growth in velocity can already be seen in the quarterly GNP and money data. From the first quarter of 1983 to the second quarter of 1984 (latest data available), the velocity of M1 has increased 3.4 percent. This is somewhat higher than the trend growth in velocity for the thirty years from 1951 to 1981, and about equal to the growth in velocity in a typical business cycle expansion.

Theoretical Appendix

1. Money Market Equilibrium

   LM: $\ln (M^*) = \alpha_1 \ln (GNP^*) - \alpha_2 (R)$
2. Goods Market Equilibrium

   IS: $\ln (GNP^*) = -\beta_1 (R^*) + \beta_2 (Z)$

   Z is all variables which affect GNP, other than the real interest rate (R^*).
3. Fisher Equation

   $R = \dot{P}^e + R^*$

Solve for Velocity

4. $\ln (V) = \ln (GNP^*) - \ln (M^*)$

   Use (1) to substitute into 4 to eliminate M^*.
5. $\ln (V) = (1 - \alpha_1) \ln(GNP^*) + \alpha_2(R)$

   Use (2) to substitute into 5 to eliminate GNP^*.
6. $\ln (V) = (1-\alpha_1)(-\beta_1 R^* + \beta_2 Z) + \alpha_2 (R)$

   $\ln (V) = -(1-\alpha_1)\beta_1 R^* + (1-\alpha_1)\beta_2 Z + \alpha_2 (R)$

   Use (3) to substitute into (6) to eliminate R^*.
7. $\ln (V) = -(1-\alpha_1)\beta_1 (R-\dot{P}^e) + (1-\alpha_1)\beta_2 Z + \alpha_2 (R)$

   $= -(1-\alpha_1)\beta_1 R + (1-\alpha_1)\beta_1 \dot{P}^e + (1-\alpha_1)\beta_2 Z + \alpha_2 R$

Combining coefficients on R yields the following Estimating Equation

8. $\ln V = [(1-\alpha_1)\beta_2 Z] + [\alpha_2-(1-\alpha_1)\beta_1] R + [(1-\alpha_1)\beta_1] \dot{P}^e$

Estimating Equation

9. $\ln(V) = a_0 + a_1 R + a_2 \dot{P}^e$

	a_0	$a_1 R$	$a_2 \dot{P}^e$
	Constant Term: Expected value of coefficient (ambiguous)	Nominal Interest Rate (ambiguous)	Inflation (positive)

FOOTNOTES

1. See M.W. Keran, "Velocity and Monetary Policy in 1982", *Weekly Letter*, March 18, 1983; J. Judd, "The Recent Decline in Velocity: Instability in Money Demand or Inflation?", *Economic Review*, Spring, 1983; J. Judd and R. McElhattan, "The Behavior of Money and the Economy, 1982-83", *Economic Review*, Summer 1983, Federal Reserve Bank of San Francisco.

2. Factors other than change in inflation expectations can also have permanent (that is, non-business cycle) effects on velocity. In principle, any factor that can have a permanent effect on nominal interest rates, and therefore money demand, without a permanent effect on GNP will affect velocity. It is the contention of this paper that historically only changes in inflation expectations have had such an impact. This issue is further discussed in the theory section of this paper.

3. In this discussion we will invoke the standard Keynesian assumption of an unchanging price level. However, we will allow for changes in inflation expectations. This seeming anomaly can be explained along the following lines. The assumption of an unchanged price level describes the price level "today", while changes in inflation expectations describe what people expect to happen to prices "tomorrow". This assumption greatly simplifies the exposition without doing violence to reality in the short-run analysis. This price level assumption is then relaxed to analyze the longer run implications of the model.

4. The rise in velocity would occur from two sources: (1) the rise in nominal interest rates would reduce the real money demand for any level of real GNP, (2) the rise in real GNP could lead to a less than proportional increase in money demand.

5. The emergence of structural budget deficits as a result of the tax and spending decisions made by the Reagan Administration in mid-1981 have probably raised real and nominal interest rates. To the extent that the tax cuts stimulated permanent increases in the level of capital, labor and technology, they would be associated with permanently higher real GNP, higher real and nominal interest rates, and a higher level of velocity. To the extent that the tax cuts only encouraged consumption, and not investment, they would leave the steady state level of real GNP unchanged (or perhaps lower), and lead to a rise in real interest rates without a depressing effect on business cycle real GNP because of the offsetting stimulus of the deficit. In either case, it is likely that the above-trend rise in velocity in 1981 was due to the parallel rise in real and nominal interest rates associated with the emergence of structural deficits. It is, however, beyond the scope of this paper to analyze this issue in detail.

6. Two elaborating points can be made about this equation. 1) In the theoretical appendix, the estimating equation is derived from a structural model in which interest rates are presented in percentage form. In the actual estimation of the equation, however, the interest rate is presented in natural log form. The results are substantially the same either way, except for the period 1934–40 when the level of interest rates was very low. The interest rate in natural log form has more variation in this period and, by the same token, better tracks the change in velocity. 2) From a statistical perspective, if the movement in nominal interest rates was in lock step with inflation expectations at all times, that is, real interest rates were constant, then it would be impossible to estimate statistically the partial effects of both variables on velocity. However, as can be seen in Chart 4 and as confirmed in the statistical analysis, there is sufficient variance in these two series to estimate statistically significant partial effects on velocity.

7. M1 is not as easy to measure as nominal interest rates because: (1) M1 is subject to revisions after the fact when more complete data is available on transactions deposits and currency holdings. These "benchmark" revisions of M1 have been substantial in the past when a large body of deposit creating institutions did not report regularly to the Federal Reserve. This problem, however, has been largely solved since the Monetary Control Act of 1980 mandated frequent reporting of data by all deposit creating institutions. (2) M1 is subject to major monthly and quarterly swings for seasonal reasons. These seasonal changes in M1 demand (for example, increased demand during the Christmas season) will not affect future GNP and must be distinguished from changes in M1 supply induced by central bank action, which will have an effect on future GNP. Seasonal adjustment techniques have been developed to deal with this issue, but there can be substantial revisions in the seasonally adjusted data—as much as one year after the fact—which can reduce the role of M1 as a guide to policy. It is important to recognize that this problem applies only to monetary policy within a year, because the seasonal adjustment by definition is washed out over the year. Even within a year, the quantitative importance of seasonal revisions has been relatively minor. The largest six-month revision in recent history was 1 percent in the second half of 1983. This revision is well within the standard error of the money/GNP link of approximately 2½ percent.

8. See Milton Friedman and Anna Schwartz, *Monetary History of the United States* (1963), for a detailed discussion of this period. Their work provides convincing evidence that the line of causation runs from central bank actions to the money supply to income.

In World War II and the immediate post-war period (1941-1951), there was a weaker association between money and income than during either the interwar period or the postwar period. The reason was that price controls understated the rate of growth of nominal income relative to money during the war and overstated it after the war when the controls were removed.

9. During World War II and continuing until 1951, the Federal Reserve kept U.S. interest rates at very low levels to minimize the cost of financing the rapid increases in the national debt. The accord freed the Federal Reserve from this interest rate pegging function.

10. See Judd and Scadding, "The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature", *Review of Economic Literature*, December 1982. They conclude that an analysis of all the empirical evidence

on the 1975-76 period supports the proposition that there was a statistically significant decline in the demand for M1.

11. The Board of Governors described its policy for the year 1930 as one of "monetary ease...(with) the progressive reductions in Reserve Bank discount and acceptance rates." See Friedman and Schwartz, *Monetary History of the United States*, p. 374-375. The dominant view within the Federal Reserve System is reflected in the following quotes based on the exchange of letters among Federal Reserve Governors, July 1930. John Calkins of San Francisco stated that "with credit cheap and redundant, we do not believe that business recovery will be accelerated by making credit cheaper and more redundant." George W. Norris of Philadelphia stated his view, "of the fruitlessness and unwisdom of attempting to depress still further the abnormally low interest rates now prevailing." *Ibid.*, p. 372. One exception to this easy monetary policy during the early 1930s was in September 1931, when the Federal Reserve raised the discount rate by the then-unprecedented amount of one percentage point in response to Great Britain leaving the gold standard.

12. See. M.W. Keran, "An Evaluation of Federal Reserve Actions 1933-68," in Federal Reserve Bank of St. Louis' *Review*, July 1969.

13. The same set of economic assumptions discussed in Section II also show that the elements that make up velocity (GNP and M1) can have an important effect on nominal interest rates and inflation expectations. This creates what statisticians call a simultaneous equation problem, that is, the association can go from interest rates and inflation to velocity or from velocity to interest rates and inflation. If the direction of causation cannot be identified, then we have a problem. At best, the coefficients would be biased, and at worst, we may be estimating a reverse causation from velocity to interest rates and inflation. The simultaneous equation problem is dealt with as follows in this article. With respect to inflation, the link between money and income on the one hand and inflation on the other is sufficiently long that the current values of inflation can be considered independent of the current values of velocity. Thus, from a statistical point of view, we can assume that changes in inflation are not caused by current changes in velocity. With respect to nominal interest rates, two factors operate: (1) During much of the period considered in this study, nominal interest rates were a primary Federal Reserve control variable. Thus, they can be at least partially treated as a policy variable, especially prior to the 1970s, before money supply targeting became more explicit. (2) To the extent that the Fed did not attempt to control nominal interest rates on an annual average basis (as used in this article), there will be some endogeneity in the interest rate and a potential bias in the estimated coefficients. However, based on past money demand and velocity studies, this bias is apt to be small.

14. A case can be made to use both a short- and a long-term interest rate. The short-rate is considered most appropriate for the LM curve, and the long-rate for the IS curve. The short rate is used in estimating these equations for two reasons. From a theoretical point of view, the analysis suggests that most of the variance in velocity comes from changes in demand for money, rather than from changes in demand for goods. From a statistical point of view, it is more reasonable to assume that the central bank controls short-term rather than long-term interest and thus is statistically more exogenous. (See previous footnote for further discussion of this issue.)

15. Many combinations and permutations of this equation were estimated to test for structural stability. For example, the equation was estimated with and without the 1941–51 period, with and without dummy variables. It was also estimated for shorter time periods, such as 1952-83. None of these changes resulted in significant changes in the coefficient values.

16. The estimated error in the table is only one-half the standard error of the equation. However, the size of the standard error in the equation is dominated by the 1922-40 period, when velocity changes were much larger than in the post-war period. The error for 1982-83 is about in line with the average error for 1952-83.

17. Technically, this is a money demand equation rearranged to put GNP rather than M1 on the left-hand side. It does, however, help to point out an important perspective of this article. While there are times when velocity changes can lead to large unexpected changes in GNP not associated with money growth, those episodes will tend to be relatively infrequent.

18. There is a problem with this equation because either M1 or nominal interest rates can be treated as an exogenous policy variable, but not both simultaneously. One way to overcome this problem is to estimate the equation with changes in inflation rather than changes in interest rates as an independent variable. This deals with the statistical problem because the effects of money on inflation typically occur with a long lag, that is, changes in inflation constitute a predetermined variable. The results of estimating an equation in this form is given below.

$$\underset{}{\Delta \ln (GNP^*)} = \underset{(1.5)}{.013} + \underset{(6.0)}{.80}\Delta \ln (M1^*) + \underset{(5.6)}{.0063}\Delta (\dot{P})$$

R^2/SE .59/.035
DW/Rho 2.12/.39
(3.0)

The results are substantially the same as in the interest rate version. M1 has a roughly proportional effect on GNP, except in those circumstances when there is a major change in the inflation rate. Inflation's effect on GNP is in line with its effect on velocity.